sordidus could be the result of variable reproductive success. Male reproductive success of *A. sordidus* at Johnston Atoll varied from 1 to 20 clutches spawned in a 4-month period (6). Data on females were not available. Those males with high reproductive output would presumably have lower lipid and contaminant content due to the shedding of gametes and the high energetic cost of defending a nest site. Lipid content in whole fish is usually five to six times higher than in fillets, with a median of 40% less analyte found in fillets (11). Thus, even though the analysis of whole fish without viscera yields a somewhat lower contaminant estimate, the measurements are relative and comparison among individuals is still accurate.

The small variation in age by site compared to the large variation in PCB concentrations suggests that for this species of damselfish, lipid content and age or exposure period were not the main factors that determined PCB bioaccumulation. The pattern of PCB accumulation in *A. sordidus* at Johnston Atoll was independent of age (exposure duration), which is consistent with the patchy distribution of PCB contamination found in the sediments.

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Comparative Settlement Age of Damselfish Larvae (*Plectroglyphidodon imparipennis,* Pomacentridae) from Hawaii and Johnston Atoll

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Most reef fishes have a planktonic larval phase with durations in the pelagic ocean habitat ranging from a few weeks to months. The pelagic larval duration (PLD) is an important factor associated with biogeographic distributions of reef fish populations (1, 2, 3, 4). The key question is this: to what degree are larvae passively advected and distributed by ocean currents, or are larvae somehow retained near natal habitats (5)? Schultz and Cowen (4) examined this issue of local retention *versus* long-distance transport of reef fish larvae to Bermuda. The PLDs for fish larvae newly settled on Bermuda reefs were compared with ocean current transport times. They found that the PLDs in their samples were similar to results obtained elsewhere in the fish's geographic range. Their conclusion was that fish larvae spawned in Bermuda were retained locally.

In this study, I compared the ages of settlement-stage larvae of the pomacentrid *Plectroglyphidodon imparipennis* (Vaillant and Sauvage, 1875) collected near Johnston Atoll and the island of Hawaii (Fig. 1a, b). If the source of recruitment of fishes to Johnston Atoll is the Hawaiian Islands, then PLDs of the larvae collected from Johnston Atoll should be longer than those of the larvae collected near their point of origin in Hawaii. If larvae spawned locally on Johnston Atoll and Hawaii are retained near their natal habitats and recruitment is from the local population, then the PLDs from both locations should be very similar. Both Hawaii and Johnston Atoll have mesoscale eddies and other current patterns that may enhance local retention of ichthyoplankton (Fig. 1c) (5, 6, 7). Ocean circulation may also transport larvae across the distance from Hawaii to Johnston Atoll as shown by the drift tracks of current drogues (see below).

Johnston Atoll (16°45′N, 169°30′W) is an isolated coral reef habitat in the central Pacific Ocean. The nearest other reefs are Midway Atoll (about 460 nautical miles, nm, north), Oahu, Hawaii (about 717 nm northeast), and Palmyra Atoll, Line Islands (about 780 nm south by southeast). The fish fauna of Johnston Atoll is a mixture of Hawaiian and Line Islands species. About 301 species of reef fishes are found on Johnston Atoll: of these 53 are endemic to Hawaii and Johnston Atoll but are not found farther south, and 11 are indigenous to Johnston Atoll and the Line Islands but are not found farther north in Hawaii (8, 9). The question is whether these island faunas

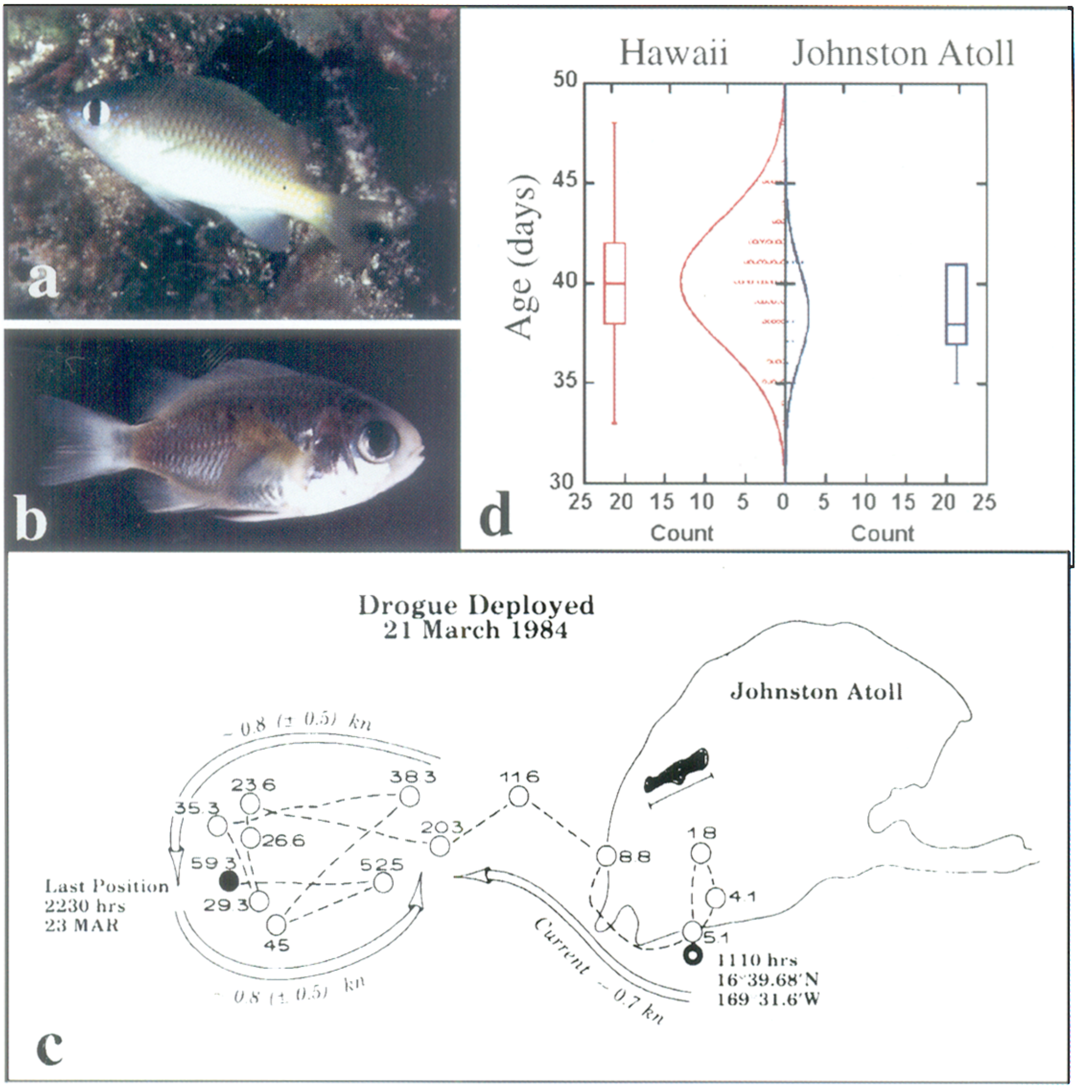

Figure 1. *(a) Adult* Plectroglyphidodon imparipennis, *about 50 mm SL. (b) Settlement-stage lava, 14.1 mm SL. (c) Track of a current drogue; deployed March 1984, showing circulation in a cyclonic ocean eddy. Position numbers are hours elapsed since deployment. For distance scale, the island (in black) is 2 miles long. (d) Age distribution of settlement-stage larvae collected from Hawaii* (n = 62) *and Johnston Atoll* (n = 10)*. A dual plot showing each datum; normal curve calculated using the sample mean and standard deviation is shown on the center vertical axis and a box plot displays sample median, quartiles, and outliers.*

are continually exchanging larvae or if the biogeographic distributions of adult fishes resulted from rare instances of larval dispersal and transport. If the faunas were originally established by rare transport events, can island populations subsequently maintain themselves with local larval retention?

Plectroglyphidodon imparipennis is a small omnivore common on shallow reefs. The species has a very broad tropical distribution from East Africa to Hawaii, the Line, Marquesan, and Pitcairn Islands; north to the Ryuku and Bonin Islands; south to New Caledonia and Rapa; throughout Micronesia and the Indonesian archipelago (10). The color pattern of this species varies geographically.

Settlement stage larvae were collected by "nightlighting"; a bright light was suspended in the water near the surface. Larvae attracted to the light were caught in a handnet and then preserved in 90% ethanol. Hawaiian larvae were collected from 20 February 1982 to 30 June 1982 within 5 nm of the coastline from Kailua-Kona to Keahou Bay, Hawaii. Johnston Atoll larvae were collected on 5 September 1983, also within 5 nm of reefs. Larval age was determined from otolith ring counts using the sagittae, the lapillae, or both. The highest ring count from a fish's otoliths was used as its age value (days). The current drogue (Fig. 1c) is the same type used by Lobel and Robinson (5).

The drift time for a passive larva to be transported from Hawaii to Johnston Atoll may range from 74 to 104 days (average 92 days). These data are from four satellite-tracked drogues during the period from February 1995 to March 1997 (11). For an active larva, the transport time should be shorter than for a purely passive drifter. Larval fish can swim vigorously during the later developmental stages of post-flexion and settlement (12, 13, pers. obs.). Even assuming that active swimming accelerates the trek, larvae arriving on Johnston Atoll from Hawaii would still be expected to be at least a few weeks older than the local Hawaiian population. This assumes that there is a minimum developmental time until the larva reaches the settlement stage and that these fish are motivated to swim to the reef habitat at their earliest opportunity. It is unknown whether larvae orient and swim directionally over vast distances and how larvae find reefs.

The PLD was estimated from otolith ring counts, which are assumed to be daily growth increments as in other pomacentrids (1, 3). The average age of larvae collected from Hawaii (n = 62) was 40 days ± 3 SD (range 33 to 48) and from Johnston Atoll (n = 10) was 39 days ± 2 SD (range 35 to 41). The youngest settlement-stage larva collected was 33 days old and the oldest was 48 days old. Thus, it appears that *P. imparipennis* is competent for recruitment after about a month in the plankton but can delay metamorphosis for at least 2 weeks more. The ages of larvae collected from Hawaii were compared to larvae from Johnston Atoll (Fig. 1d) using a two-sample t-test (SYSTAT 6.0). Two tests were computed for comparing group means: the pooled variance t-test (t = 1.528, df = 70, P = 0.131) and the separate variance t-test (t = 1.908, df = 15, P = 0.076). The difference between the means was 1.597. The pooled test assumes that population variances are equal, whereas the separate variance test does not make this assumption. Results of both tests indicate no significant difference in the age of settlement-stage larvae collected from Hawaii and Johnston Atoll.

The conclusion is that the settlement stage *P. imparipennis* collected offshore Johnston Atoll were probably originally spawned there.

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Tidal River Riffle Habitats Support High Diversity and Abundance of Gammaridean Amphipods

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Gammaridean amphipods have an important role in estuarine food webs by serving as a trophic link from primary producers to higher-order consumers. Relatively little is known of their abundance, diversity, and distribution in estuaries of the Plum Island Sound region, northeastern Massachusetts. We studied amphipod populations along the brackish tidal portion of the Rowley River estuary, part of the Plum Island Sound estuarine system in Rowley, Massachusetts, to gain a better understanding of the environmental factors that influence amphipod ecology in this region.

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A longitudinal survey was conducted during daytime low tide on 18 July 1997, to determine location and density of amphipods in hard and soft substrates. Rocks ranging in size from gravel to cobbles composed the hard substrate associated with low-tide riffles, and were variably covered with a turf of an attached chlorophyte alga (*Cladophora* sp.) and hydroids (*Cordylophora lacustris*). Soft substrate consisted of poorly sorted muds and sands associated with lentic low-tide water. Three hard-substrate and two soft-substrate sites were randomly sampled using a PVC collar (diam. = 3.5 cm) and an acrylic plastic core tube (diam. = 6.5 cm), respectively. After the longitudinal survey, one riffle habitat where the hard substrate was primarily cobble was selected for closer study. This site was sampled randomly at low tide on 23 July and 9 August 1997. The density of amphipods in three substrate cover types (bare rock, chlorophyte algal turf, and mixed hydroids and chlorophytes) was measured.